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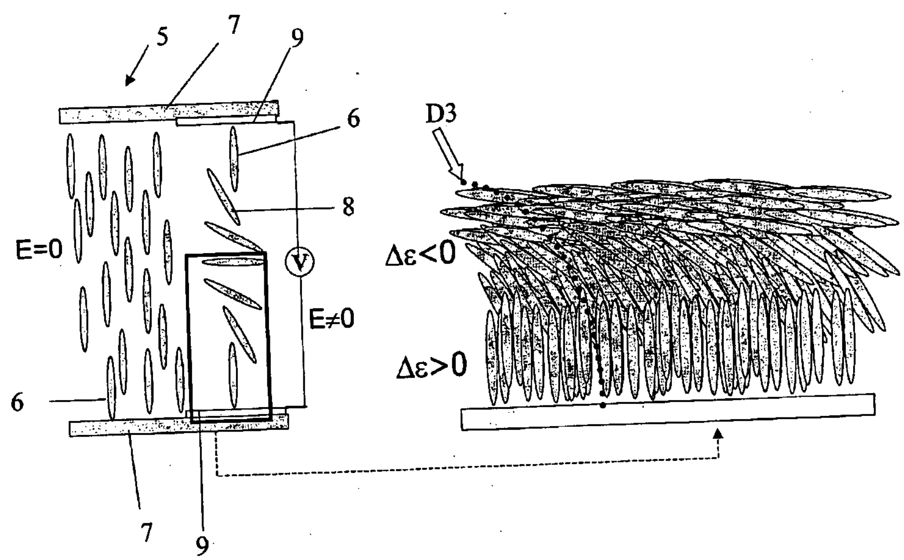
(54) Title: A LIQUID CRYSTAL DEVICE AND A METHOD FOR MANUFACTURING THEREOF



(57) Abstract: The invention relates to a liquid crystal device comprising a liquid crystal bulk layer and a surface-director alignment layer comprising side-chains arranged to interact with the bulk layer, wherein the orientation of the bulk layer molecules and the orientation of said side-chains each is directly controllable by an electric field via dielectric coupling, thus resulting in a decreased total time period (rise and decay times) needed to switch and relax the liquid crystal bulk molecules in response to an applied external field. The invention also relates to a method for manufacturing a liquid crystal device and a method of controlling a liquid crystal bulk layer.

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A LIQUID CRYSTAL DEVICE AND A METHOD FOR MANUFACTURING THEREOF

Technical field

The present invention generally relates to the field of liquid crystals. More specifically, the present invention relates to a liquid crystal device comprising a liquid crystal bulk layer presenting a surface-director at a bulk surface thereof, and a surface-director alignment layer arranged to interact with the bulk layer at said bulk surface for facilitating the obtaining of a preferred orientation of the surface-director of the bulk layer.

The invention also relates to a method for manufacturing a liquid crystal device and a method of controlling a liquid crystal bulk layer.

Technical background

Liquid crystals, widely used at present as electro-optical media in display devices, are organic materials with anisotropic physical properties. Liquid crystal molecules are generally long rod-like molecules, so-called calamitic molecules, which have the ability to align along their long axis in a certain preferred direction (orientation). The average direction of the molecules is specified by a vector quantity and is called director.

It may be noted, however, that there also exist liquid crystal molecules that are disc-like, so-called discotic molecules.

The operation of the liquid crystal displays is based on the changes of the optical characteristics, such as light transparency, light absorption at different wavelengths, light scattering, birefringence, optical activity, circular dichroism, etc, of the liquid crystal in the display caused by an applied electric field (direct coupling).

One of the basic operational principle of liquid crystal displays and devices is the switching of the orientation of the liquid crystal molecules by an applied electric field that couples to the dielectric anisotropy of the liquid crystal (dielectric coupling). Such a coupling gives rise to an electro-optic response quadratic with the applied electric field, i.e. independent of the field polarity. There exist a number of different types of LCDs (liquid crystal displays) whose operation is based on dielectric coupling, especially dynamic scattering displays, displays using deformation of homeotropically aligned nematic liquid crystal, Schadt-Helfrich twisted nematic (TN) displays, super twisted nematic (STN) displays, in-plane switching (IPS) nematic displays.

For modern applications, a LCD should possess several important characteristics, such as a high contrast and brightness, a low power consumption, a low working voltage, short rise (switching) and decay (relaxation) times, a low viewing angle dependence of the contrast, a grey scale or bistability, etc. The LCD should be cheap, easy to produce and to work with. None of the prior-art LCDs is optimised concerning all the important characteristics.

A nematic liquid crystal material exhibits the simplest liquid crystalline structure , i.e. an anisotropic liquid. In a nematic material, the liquid crystal molecules are aligned toward a particular direction in space, but the centre of mass of molecules is not ordered.

In most of the conventional nematic liquid crystal displays, operating on the basis of the dielectric coupling, the electric field is applied normally to the liquid crystal bulk layer (i.e. normally to the confining substrates) and the liquid crystal bulk molecules are switched by the electric field in a plane perpendicular to the confining substrate surfaces (so-called out-of-plane switching). These displays are usually slow, and

nearly all suffer from non-satisfactory angular dependence of the contrast.

There is also another type of LCDs with in-plane switching, in which the electric field is applied along the liquid crystal bulk layer (i.e. in parallel with the confining substrates) and the liquid crystal bulk molecules are switched in a plane in parallel with the confining substrate surfaces. These displays exhibit a very small angular dependence of the image contrast but the resolution and the switching time are not satisfactory.

In the liquid crystal displays discussed above, the desired initial alignment of the liquid crystal layer in the absence of an external field, such as an electric field, is generally achieved by appropriate surface treatment of the confining solid substrate surfaces, such as by applying a so-called (surface-director) alignment layer (also called orientation layer) on the confining substrate surfaces facing said liquid crystal bulk. The initial liquid crystal alignment is defined by solid surface/liquid crystal interactions. The orientation of the liquid crystal molecules adjacent the confining surface is transferred to the liquid crystal molecules in the bulk via elastic forces, thus imposing essentially the same alignment to all liquid crystal bulk molecules.

The director of the liquid crystal molecules near the confining substrate surfaces (herein also called surface-director) is constrained to point in a certain direction, such as perpendicular to (also referred to as homeotropic or vertical) or in parallel with (also referred to as planar) the confining substrate surfaces. The type of alignment in liquid crystal displays operating on the coupling between liquid crystal dielectric anisotropy and applied electric field is chosen in accordance with the sign of the dielectric anisotropy, the direction of the applied electric field and the desired type of switching mode (in-plane or out-of plane).

In out-of-plane switching liquid crystal cells employing a liquid crystal bulk having a negative dielectric anisotropy, it is important to uniformly orient the director of the liquid crystal bulk molecules (in the field-off state) vertically to the substrate surfaces (so-called homeotropic alignment).

An example of a method for establishing a homeotropic alignment comprises coating the confining substrate surfaces with a surfactant, such as lecithin or hexadecyltrimethyl ammonium bromide. The coated substrate surfaces is then also preferably rubbed in a predetermined direction, so that the field-induced planar alignment of the liquid crystal molecules will be oriented in the predetermined rubbing direction. This method may give good results in laboratory studies, but has never found industrial acceptance due to that long term stability is not obtained as the alignment layer is slowly dissolved in the bulk liquid crystal (J. Cognard, Mol. Cryst. Liq. Cryst., Suppl. Ser., 1982, 1, 1).

In out-of-plane switching liquid crystal cells employing a liquid crystal bulk having a positive dielectric anisotropy, it is important to uniformly orient the director of the liquid crystal bulk molecules (in the field-off state) in parallel with the substrate surfaces (so-called planar alignment). For twisted nematic liquid crystal cells, it is also important to orient the liquid crystal bulk molecules at a certain inclined orientation angle (pre-tilt angle) to the substrate.

Known methods for establishing planar alignment is, for instance, the inorganic film vapour deposition method and the organic film rubbing method.

In the inorganic film vapour deposition method, an inorganic film is formed on a substrate surface by vapour-deposition of an inorganic substance, such as silicon oxide, obliquely to the confining substrate so that the liquid crystal molecules are oriented by the inorganic film in a certain direction depending on the inor-

ganic material and evaporation conditions. Since the production cost is high, and the method thus is not suitable for large-scale production, this method is practically not used. According to the organic film rubbing method, an organic coating of, for instance, polyvinyl alcohol, polyoxyethylene, polyamide or polyimide, is formed on a substrate surface. The organic coating is thereafter rubbed in a predetermined direction using a cloth of e.g. cotton, nylon or polyester, so that the liquid crystal molecules in contact with the layer will be oriented in the rubbing direction.

Polyvinyl alcohols (PVA) are commercially rarely used as alignment layers since these polymers are hydrophilic, hygroscopic polymers that may adsorb moisture adversely affecting the molecular orientation of the polymer and thus the liquid crystal device performance. In addition, PVA may attract ions which also impairs the liquid crystal device performance.

Also polyoxyethylenes may attract ions, thus resulting in impaired liquid crystal device performance.

Polyamides have a low solubility in most commonly accepted solvents. Therefore, polyamides are seldom used commercially in liquid crystal device manufacturing.

Polyimides are in most cases used as organic surface coating due to their comparatively advantageous characteristics, such as chemical stability, thermal stability, etc.

In in-plane switching liquid crystal cells employing a liquid crystal bulk having a positive or negative dielectric anisotropy, it is important to uniformly orient the director of the liquid crystal bulk molecules in parallel with the substrate surfaces. The aligning methods used in this case are similar to those used for out-of-plane switching of liquid crystal cells employing a liquid crystal bulk having a positive dielectric anisotropy.

In in-plane switching liquid crystal cells employing a liquid crystal bulk having a positive dielectric ani-

PCL XL error

Subsystem: IMAGE

Error: ExtraData

Operator: ReadImage

Position: 4331

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21. ☒ Applicant(s) requests that the published application include the following assignment information:
ECSIBEO PPF2 AB, Goteborg, Sweden

22. ☒ The following fees are submitted:

					CALCULATIONS	PTO USE ONLY
Basic Filing Fee (1631)					$ 300.00	
Surcharge of $130.00 (1617) for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).						
CLAIMS	NUMBER FILED		NUMBER EXTRA	RATE	$	
Total Claims	20	-20 =	0	x $50.00 (1615)	$ 0.00	
Independent Claims	3	- 3 =	0	x $200.00 (1614)	$ 0.00	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)				+ $360.00 (1616)		
Examination Fee				+ $200.00 (1633)	$ 200.00	
Search Fee				+ $500.00 (1632)	$ 500.00	
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TOTAL OF ABOVE CALCULATIONS					$ 1,000.00	
☒ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.				+	$ 500.00	
SUBTOTAL =					$ 500.00	
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Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 (8021) per property +					$ 40.00	
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a. ☒ A check in the amount of $ 540.00 to cover the above fees is enclosed.

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NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

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